IN THE TITLE:

Amend the title to read as follows:

IN-VEHICLE ELECTRIC LOAD DRIVE/CONTROLLING DEVICE INCORPORATING POWER MOSFET THERMAL PROTECTION

IN THE SPECIFICATION:

Replace the paragraph beginning on page 1, line 6 with the following paragraph:

This invention relates to an in-vehicle load drive-controlling device for controlling energization of an in-vehicle electric load~~, andmoreparticularly~~ and, more particularly, to an in-vehicle load drive-controlling device for protecting a power switching element such as a power MOSFET from an excessive current.

Replace the paragraph beginning on page 1, line 12 with the following paragraph:

A previously known circuit for protecting a power MOSFET for drive-controlling the in-vehicle electric load from an excessive current is disclosed in, e.g., JP-A-2000-193692 which proposes an excessive current detecting circuit and an excessive current detecting/protecting circuit.

Replace the paragraph beginning on page 1, line 19 with the following paragraph:

In Fig. 21, a series circuit composed of a reference resistance Rr and a reference MOSFET QB, which constitutes a reference circuit, is connected in parallel [[to]] with a series circuit composed of a load L and power MOSFET QA. The reference resistance Rr and the reference MOSFET are equivalent to the load L and the power MOSFET QB, respectively. On the basis of a difference between the drain-source voltage of the reference MOSFET QB through which a reference current flows and that of the power MOSFET QA in which the current is varied by an excessive current, the excessive current flowing through the power MOSFET is detected.

Replace the paragraph beginning on page 2, line 4 with the following paragraph:

Such an excessive current detecting circuit is ~~implementedasanintegratedcircuitsothat thereferenceMOSFET~~ implemented as an integrated circuit so that the reference MOSFET QB and the power MOSFET QA are formed on the same chip by the same process and both of them are composed of a plurality of transistors.

Replace the paragraph beginning on page 2, line 9 with the following paragraph:

In a conventional excessive current detecting circuit, ~~since~~ because the power MOSFET QA, which is a switching element, and a reference power MOSFET QB, which is also [[the]] a switching element, are integrated to ~~constitute~~ form an IC excessive current detecting circuit, the structure of each element is ~~complicate~~ complicated and the control circuit therefore is also ~~complicate~~ complicated.

Replace the paragraph beginning on page 2, line 20 with the following paragraph:

The gate control circuit for the power MOSFETs QA and QB, which includes MOSFETs Q1 and Q2, a comparator CP, etc., and a loadline are coupled with each other by a terminal T3. Therefore, the control circuit may malfunction or may be broken ~~due to~~ as a result of the noise from the load line.

Replace the paragraph beginning on page 3, line 3 with the following paragraph:

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An object of [[this]] the present invention is to provide an in-vehicle electric load drive-controlling device which can be simplified in circuit configuration and improved in safety and reliability from the viewpoint of protection from excessive current and exclusion of influence of external noise.

Replace the paragraph beginning on page 3, line 8 with the following paragraph:

A10

In order to attain the above object as seen from Fig. 1A, in accordance with [[this]] the present invention, there is provided an in-vehicle load drive-control circuit comprising:

a power MOSFET between connected in series between a load L and a power source B, the power MOSFET on/off controlling the power supply to the load, the power MOSFET incorporating a thermoelectric element D across which the voltage drops ~~owing to~~ as a result of heat liberation when the power MOSFET is energized; and

a control means COT for ON/OFF controlling a gate driving signal to the power MOSFET on the basis of a voltage drop,

wherein after the voltage has been stabilized, the gate driving signal is made constant.

Replace the paragraph beginning on page 3, line 20 with the following paragraph:

A11

In this configuration, the temperature change of the thermoelectric element incorporated in the power MOSFET is detected in terms of a voltage change to detect heat liberation ~~due to~~ as a result of a current flowing through the MOSFET, and a gate driving signal to the power MOSFET

is ON/OFF controlled and is made constant after the voltage of the thermoelectric element has been stabilized. This configuration inhibits the breakage of the MOSFET due to excess current in a simple structure.

Replace the paragraph beginning on page 4, line 8 with the following paragraph:

In this configuration, when the abrupt voltage drop across the thermoelectric element is detected ~~owing to~~ as a result of the rush current flowing through the load which is ten times as large as the rated current when the power supply to the load is initially turned on, the gate driving signal is interrupted, and after the voltage across the thermoelectric element rises to the stationary level, the gate driving signal is produced. Such a configuration inhibits the breakage of the MOSFET due to the excess rush current when the power MOSFET is initially turned on.

Replace the paragraph beginning on page 6, line 2 with the following paragraph:

Preferably, the control unit ~~comprises~~ includes an overheat detecting unit DT13 for detecting an overheat abnormality of the power MOSFET when the voltage drops to produce an interrupting signal for the gate interrupting signal.

Replace the paragraph beginning on page 6, line 16 with the following paragraph:

Preferably, the thermoelectric element D is a diode whose forward voltage increases with an increase in an ambient temperature. In this configuration, since the diode can be manufactured on the same pellet in the same manufacturing step as the MOSFET [[is]], the overheat of the MOSFET due to the excess current can be effectively detected.

Replace the paragraph beginning on page 6, line 22 with the following paragraph:

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Preferably, as seen from Fig. 1B, the in-vehicle load drive controlling device further ~~comprises~~ includes a plurality of power MOSFETs Q1 to Q4 for driving a plurality of loads LM1 to LM4, respectively, and the control unit supplies gate driving signals at slight intervals over time to the gates of these MOSFETs.

Replace the paragraph beginning on page 9, line 26 with the following paragraph:

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As seen from Fig. 2, this device includes a power MOSFET Q, a control circuit CO and a switch SW. The power MOSFET Q ~~aswellasaloadLisconnectedbetween+terminalofaninvehicle~~ as well as a load L is connected between the "+" terminal of an in-vehicle battery B and ground, and incorporates temperature detecting diodes D10 and D20 in a series connection (series-connected diodes). The control circuit CO serves to supply a control signal to the power MOSFET Q and perform the transient heat protection, overheat protection and excessive current protection for the power MOSFET Q on the basis of the forward voltage Vf of the series connected D1, D2 the forward voltage of which is varied due to heat liberation of the MOSFET. The switch SW serves to supply a load driving signal to the control circuit CO.

Replace the paragraph beginning on page 10, line 13 with the following paragraph:

A17

The power MOSFET Q according to this embodiment may be a vertical DMOS configured MOSFET, as shown in Fig. 3.

Replace the paragraph beginning on page 10, line 15 with the following paragraph:

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As ~~seen from~~ shown in Fig. 3, a Si semiconductor substrate is composed of two n type layers N+ and N-. A metallic wiring M is deposited on the rear surface of the n type layer N+. A drain electrode is formed on the metallic wiring M. P- well regions are formed apart from each other in the surface of the n type layer N-. Within each of the P- well regions, two N+ well regions are formed so as to sandwich a P+ well.

Replace the paragraph beginning on page 11, line 12 with the following paragraph:

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The diode is electrically insulated from the gate electrode and source electrode which ~~constitute~~ form the switch element. Therefore, there is less danger that transmission noise is conducted from the load line connected to the source electrode to the control circuit.

Replace the paragraph beginning on page 12, line 17 with the following paragraph:

A20

In order to satisfy the above condition, the circuit CO for controlling the gate voltage VG and source voltage VS of the MOSFET Q includes a constant current circuit I, a Vf detecting circuit DT3, an overheating detecting circuit DT1, a transient heat detecting circuit DT2 and a level shift circuit LS. The constant current circuit I supplies a constant current to the diodes D10 and D20 built in the MOSFET Q. The Vf detecting circuit DT3 includes a buffer amplifier for detecting the forward voltage across the diodes D10, D20 in a state where the forward current is being supplied to the diodes D10, D20 from the constant current circuit I. The overheating detecting circuit DT1 detects the overheat abnormality when the absolute value of the forward voltage Vf detected by the

Vf detecting circuit DT3 becomes lower than the overheat interrupting threshold voltage set_as shown in Fig. 10, thereby supplying an overheating abnormality interrupting signal to a gate control circuit GC. The transient heat detecting circuit DT2 supplies a transient heat interrupting signal to the gate control circuit GC when the time change of the forward voltage Vf exceeds the transient heat interrupting threshold value as shown in Fig. 8. The level shift circuit LS boosts the potential of the gate driving signal produced from the gate control circuit GC to a level higher than the battery voltage to be supplied to the drain of the MOSFET and supplies Vgs thus obtained between the gate and source of the MOSFET.

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Replace the paragraph beginning on page 16, line 9 with the following paragraph:

The collector and emitter of a transistor (NPN) Q1 are ~~connectedbetweentheoutputsideofthe voltageboostingcircuit~~ <u>connected between the output side of the voltage boosting circuit</u> and ground, whereas the base thereof is connected to the output from the inverter V2 through a resistor R16. A gate driving signal is inputted to the input terminal of the inverter INV.

A21

Replace the paragraph beginning on page 17, line 15 with the following paragraph:

At this time, the transistors Q5 and Q4 are in the ON state ~~owing to the gate driving signal at the H level~~ <u>as a result of the gate driving signal at the H level</u>. Therefore, the charges stored in the capacitor 12 are applied to the gate of the MOSFET Q as a gate voltage VG through the transistor Q2, resistors R11, R13 and transistor Q4. The voltage resulting from superposition of the battery B1 on the charges stored in the capacitor C12 is applied to the source of the MOSFET Q. Thus, the

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voltage enough to turn on the MOSFET Q is applied between the gate and source of the MOSFET Q.

Replace the paragraph beginning on page 19, line 14 with the following paragraph:

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At this time, in response to the heat liberation of the MOSFET Q, the forward voltage Vf of the diode D10, D20 incorporated in the MOSFET Q abruptly falls. When the ~~quantity of~~ fall of the forward voltage Vf reaches a transient heat threshold value, the transient heat detecting circuit DT2 to which the forward voltage Vf has been applied supplies a transient heat interrupting signal to the gate control circuit GC so that the gate driving signal is interrupted. It should be noted that the transient threshold value is set at a value sufficiently smaller than the value where the MOSFET Q and wiring of the load circuit is thermally broken.

Replace the paragraph beginning on page 26, line 24 with the following paragraph:

A24

Further, the Vf detecting circuit detects a time changing rate of the forward voltage Vf whenever the gate driving signal by the PWM signal is supplied to the MOSFET. If the changing rate is large so that the forward voltage Vf falls from the transient heat interrupting threshold value, the transient heat interrupting circuit supplies the output signal at the H level from the comparator CMP to the D type flip flop. The D type flip-flop DFF supplies the transient heat interrupting signal at the L level (i.e., ground level) applied to the D terminal to the gate interrupting circuit GC.